Experimental Dryer for Pre-Pilot Plant Studies

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DESIGNING pilot-plant equipment with which to study the factors involved in large-scale processing of various products developed in the laboratory, experimental drying apparatus is frequently needed capable of determining the drying characteristics of different materials under widely varying conditions and of yielding data translatable to larger scale operations. Such a machine should require a small quantity of material.

In recent years, drying techniques have been aimed at achieving the most rapid rate of drying possible without introducing deleterious effects on the product and consistent with the most economical methods for handling the material. This has been accomplished in many cases by employing a through-air circulation method of drying, by which heated air is forced at high velocity through a porous bed of the material supported on a perforated-metal or screen surface. An experimental unit which meets these requirements is here described.

EQUIPMENT

Figure 1 shows a general layout of the unit. It consists essentially of a centrifugal blower, *A*, 7.5 inches in diameter with a V-belt drive from a 0.5-horsepower motor; a drying cabinet, *B*; a torsion balance, *C*, reading to 0.2 gram; an automatic wet and dry-bulb recorder-controller, *D*, having throttling control and automatic reset and equipped with a chart reading to 300° F.; an air-conditioning cabinet having a 2-row finned-tube steam coil with 39 square feet of heating surface; plus ductwork, control valves, and accessories. The entire unit is constructed of sheet metal covered with 2 inches of 85% magnesia insulation.

For supporting the material several stainless steel pans are provided, each 1 square foot in area. The bottoms are constructed of perforated metal or wire screen having apertures of various sizes for different kinds of material. Pan inserts are also provided to reduce the area of the bottom or increase the height of the walls. Nichrome wires suspended from an aluminum rod and clamped to the drying pan at its four corners pass through the roof of the drying cabinet (Figure 2). The holes in the roof are sealed with rubber stoppers.

The inside cross-sectional area of the drying cabinet is 4 square feet and the distance from the pan shelf to the roof is 2 feet. Thus when the air enters the drying cabinet, its velocity is reduced to a very low value. When the pan is elevated by the wires approximately 10 inches above the shelf and suspended from the balance on the roof, accurate weighings can be made very rapidly without shutting off the air supply and upsetting the control conditions. A further advantage of this plenum chamber above the drying pan is that it produces uniformity of air flow through the 1 square foot of drying surface of the pan without baffles or vanes.

Starting at the blower, the air flows through the upper duct to the drying cabinet. At location 1, Figure 1, is a manually operated volume-control damper, by means of which the total flow of air is regulated. The air next passes through an orifice nozzle, 2. Centrally located in the nozzle is a Pitot tube, which is connected to the upper inclined manometer on the cabinet and gives a reading of velocity head in inches of water; from this and from the temperature the volume-flow of the air is calculated. The air now enters the drying cabinet and passes down through the material in the pan. The pan rests on a shelf which forms an orifice in the drying cabinet. Static pressure openings above and below the shelf and connected to the lower inclined manometer indicate the loss in pressure as the air passes through the material and the pan. This information is vital to the design of a blower for larger equipment.

Mounted just above and behind the drying pan are the dry and wet bulbs of the air-operated temperature recorder-controller (Figure 2), by which the temperature and humidity of the air blowing on the wet material are controlled. A slight error in the wet-bulb temperature of the drying air is introduced here, since the evaporation from the wick is included in the air passing through the pan. Also entering the drying cabinet just above the pan is an iron-constantan thermocouple, connected to a potentiometer. The thermocouple lead wires are coiled, so that when the point is injected into the wet material, the pan can be raised and lowered for weighing and the additional tare due to the thermocouple will be practically constant.

As the air leaves the bottom of the pan, it passes over the sensitive portion of an industrial thermometer and then enters the return duct. Here the amount of spent air vented at 4 is automatically controlled by damper, 3, operated by a diaphragm motor which functions from the wet bulb of the controller. An equal amount of fresh air enters at 5. The recirculated air plus the fresh air then enters the conditioning cabinet.

In the conditioning cabinet the air first passes through the steam heater. The supply of steam is automatically controlled by a diaphragm valve which functions from the dry bulb of the instrument. If necessary, the heated air is then humidified by spraying steam or a fine mist of water through nozzles facing against the path of air flow. The quantity sprayed is automatically controlled by a diaphragm valve which functions from the wet bulb of the instrument. Either water or steam can be supplied to the humidifying control valve, the choice being determined by the wet-bulb temperature required.

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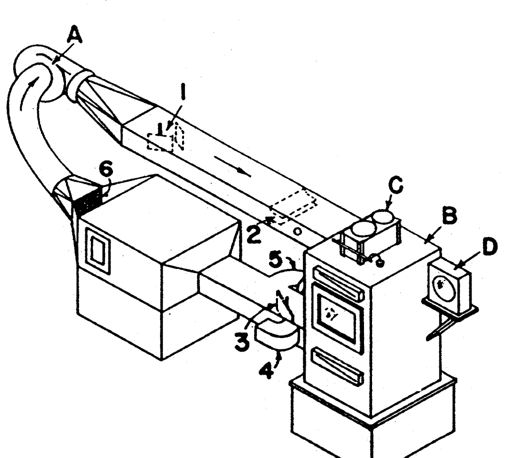


Figure 1. Dryer

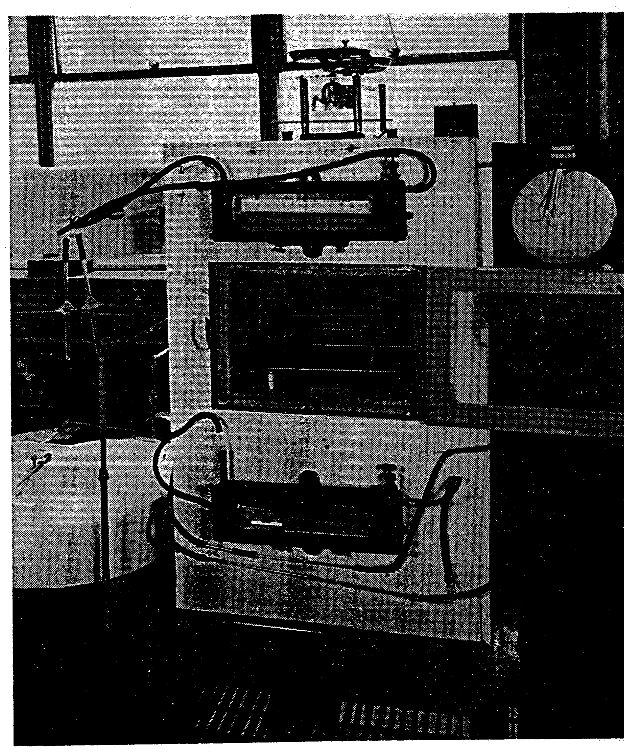
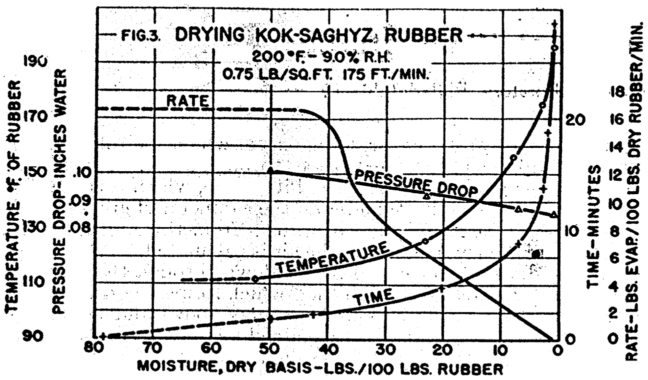


Figure 2



The conditioned air finally passes through a copper diffusing screen, 6, which eliminates any droplets of water. If the humidifying nozzles were located in the duct leading to the heater, the diffusing screen would be unnecessary. The air now returns to the blower for another cycle.

The utility of such an experimental dryer was demonstrated during the development of a pilot-plant process for extracting rubber from the Russian dandelion.

The purified rubber as extracted from the root was in the form of small discrete particles which floated in water. This material was first dewatered on a centrifuge, then spread into a drying pan having a perforated metal bottom. Studies were made to determine the optimum air temperature, velocity, depth of loading, etc. Samples from each test were checked by compounding the rubber and subjecting it to physical tests. The type of drying data obtained from a single test is illustrated in Figure 3. Air at 200° F. and 9% relative humidity was circulated at a rate of 175 c.f.m. per square foot of pan area; the tray was loaded with 0.75 pound (dry weight) of rubber per square foot.

It was demonstrated that such a heat-sensitive material could be dried very rapidly at an elevated temperature with better results and more economically than by a conventional method for drying rubber, such as vacuum drying. The data obtained made possible the operation of a pilot-plant dryer under conditions which yielded the best quality of dried rubber.